



# Potential Environmental Impacts and Water Treatment Requirements for Wastewater Produced in Oil & Gas Operations

Kenneth (KC) Carroll ([kccarr@nmsu.edu](mailto:kccarr@nmsu.edu))  
and Pei Xu ([pxu@nmsu.edu](mailto:pxu@nmsu.edu))

# Oil and Gas Produced Wastewater Disposal

NM produced water production in 2013 (NM - Oil Conservation Division)

Total = 33 billion gallons/year or 101,332 acre-feet/year

NW: San Juan, Rio Arriba, Sandoval, McKinley = 1.9 billion gallons/year

SE: Lea, Eddy, Chaves, Roosevelt = 30.4 billion gallons/year

Other: Colfax, Union, Harding = 0.7 billion gallons/year

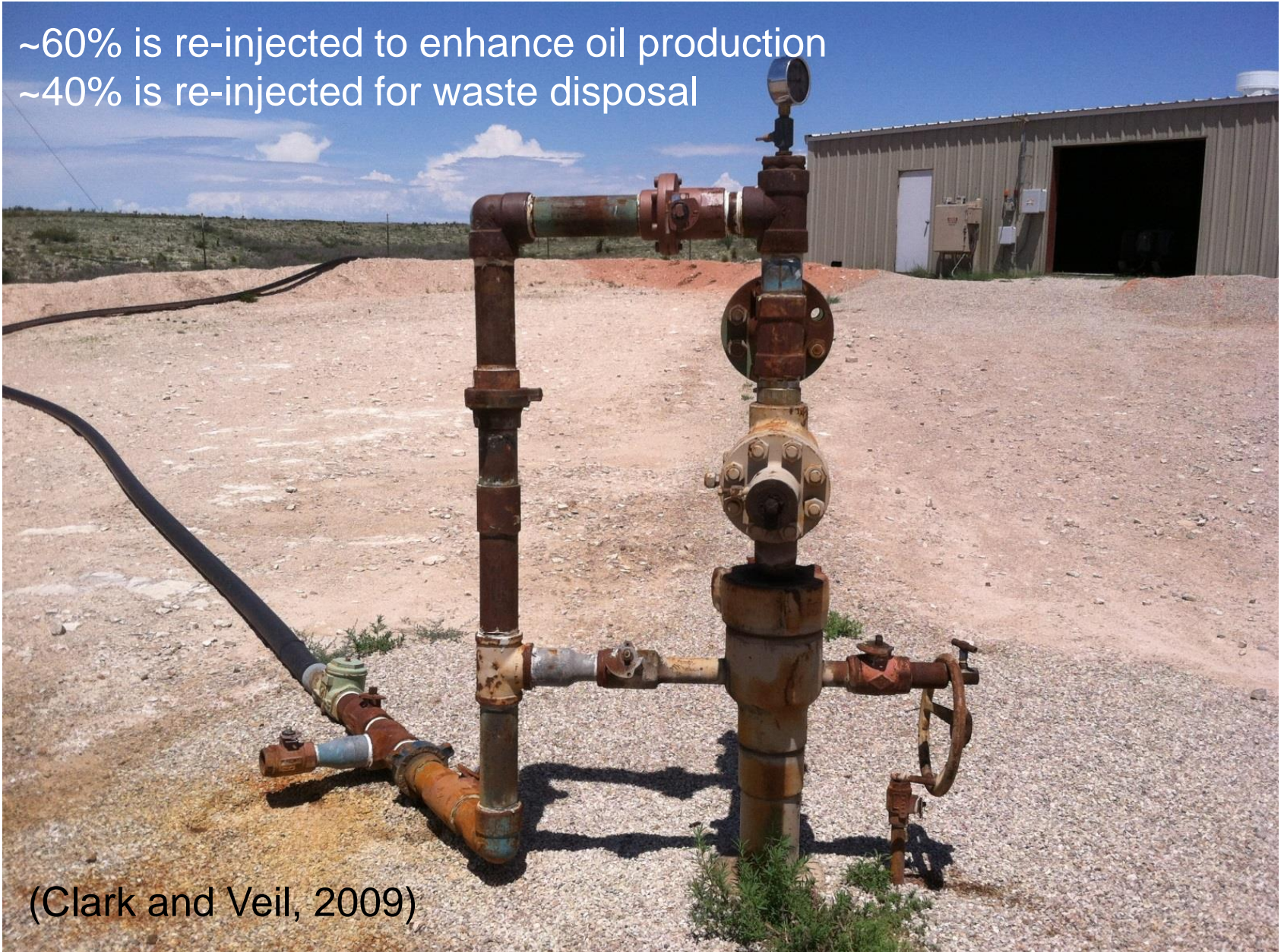
# of water producing wells in NM = 46,809 (which is 70% of total wells)





# Deep Disposal Injection Well

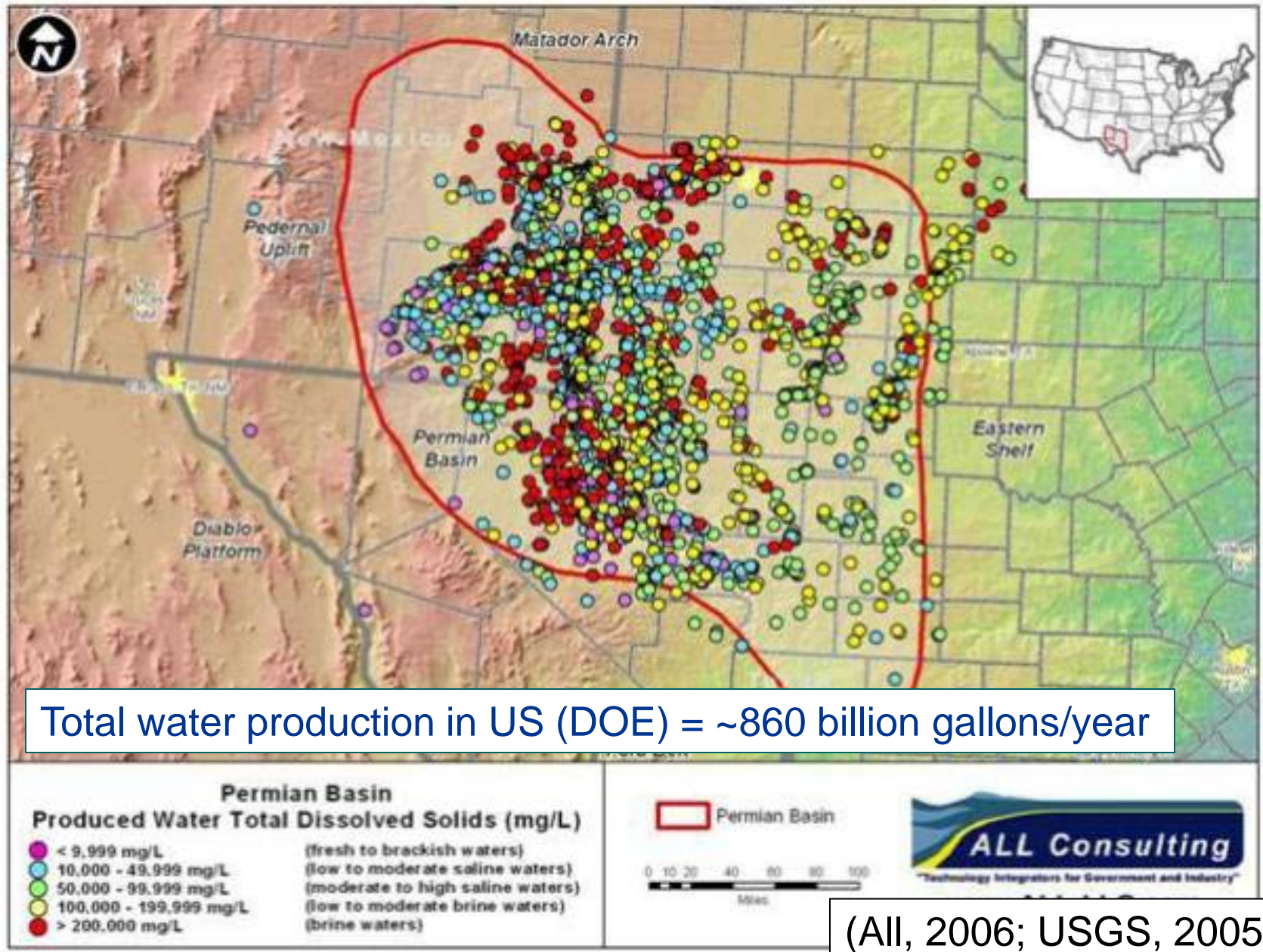
~60% is re-injected to enhance oil production  
~40% is re-injected for waste disposal



(Clark and Veil, 2009)



# Salinity distribution of produced water in Permian Basin



# Salinity distribution of produced water in Permian Basin

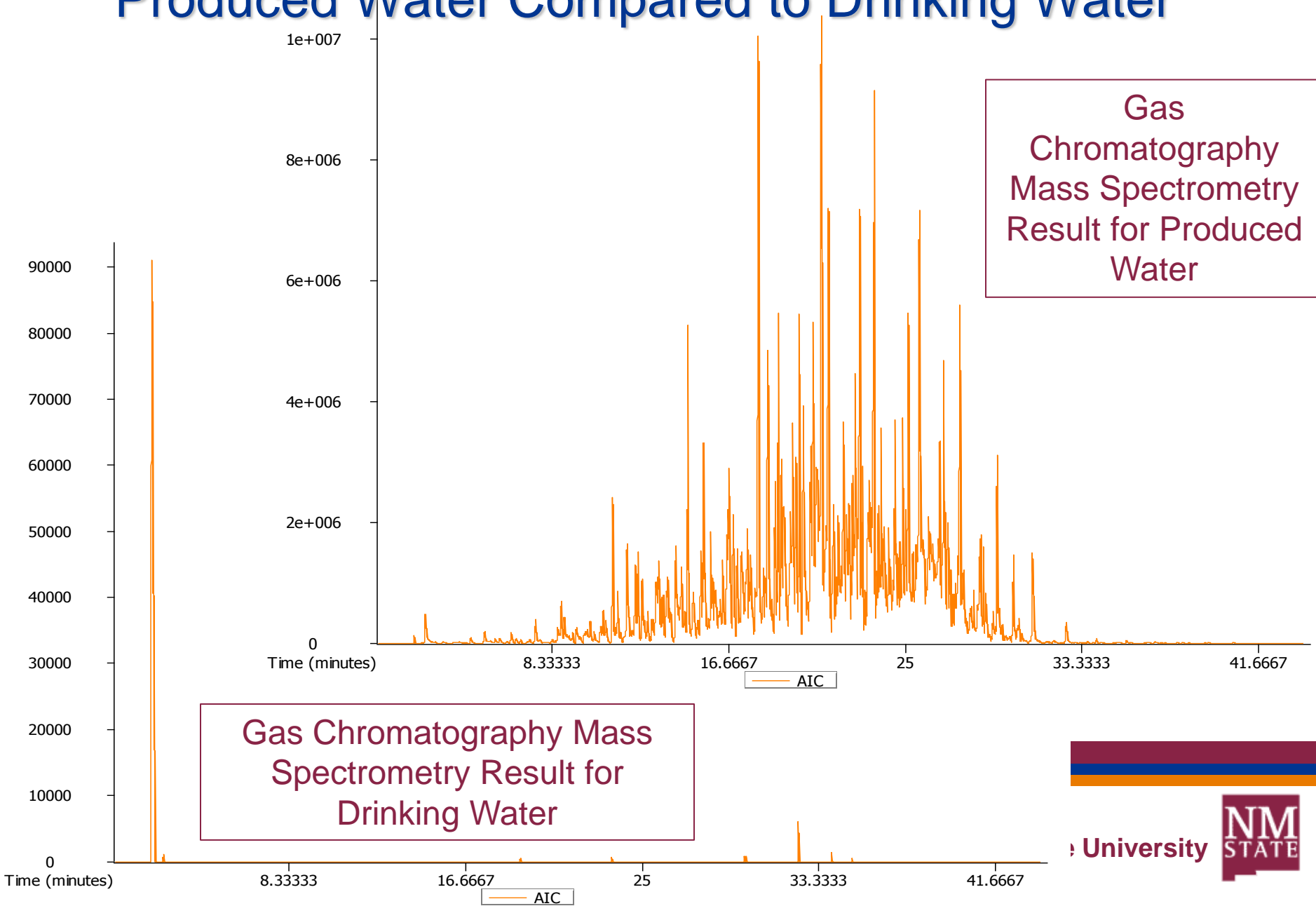
Formation	Name of Samples	Sampling location	Average Depth (ft below surface)	Total Dissolved Salts (mg/L)
Fusselman	Sample 1	Well head	10013	68990
Fusselman	Sample 5	Separator	10153	70570
Lower Cline	Sample 2	Well head	9546	79920
Lower Cline	Sample 6	Separator	9248	36790
Spraberry	Sample 7	Well head	6830	137840
Spraberry	Sample 8	Separator	7331	139430
Bone Spring	Sample 9	Water Tank	9480	102650
Lower Pennsylvanian	Sample 10	Water Tank	12000	150211
Cline	Sample 4	Well head	9489	37700
Wolf wood	Sample 3	Well head	8791	127240
Mixed (storage tank)	Sample 11	Stock tank	N/A	127560
Mixed (storage tank)	Sample 12	Stock tank	N/A	123450

# Produced Water Composition

- Produced water natural contamination:
  - Poor quality and high variability of composition
    - High salinity (10 – 250 g/L salt)
    - Hydraulic fracturing chemical additives
    - Organic compounds (petroleum hydrocarbons)
    - Metals and radioactive compounds
    - Suspended and colloidal solids



# Chemical Analysis Peaks of Compounds in Produced Water Compared to Drinking Water





# Oil and Gas Site Reclamation





# Hydraulic Fracturing Water

- Produced water reuse / recycling
  - Large water volume requirement
    - 60,000 – 1,000,000 gal/well for drilling
    - 2,000,000 – 13,700,000 gal/well for hydraulic fracturing
  - Large volume and continuous production of flowback and produced water
    - 15% - 85% of the injected water
    - High intensity of short-term flowback water
    - Low intensity of long-term produced water

# Produced Water Potential Reuse Alternatives

**Beneficial Use:** Determined by Office of the State Engineer (permits water rights) if water can be permitted as a water right (subject to appropriation) for useful or beneficial purpose.



Reuse Examples: Eldorado Biofuels <http://eldoradobiofuels.com/> (algal-derived biofuel using produced water)  
And Ochoa Water Co. (using produced water as drilling and fracturing fluid)



# Produced Water Reuse Limitations

- Produced water reuse / recycling
  - Limited treatment technologies and disposal options
    - Economic constraints
    - High salinity
    - Chemical variability
    - Geographical distribution
    - Federal and state regulations (environmental and water resource permitting and regulation issues)

# Integrated Decision-Support Framework


- Evaluate produced water treatment and beneficial use alternatives
- Format into Excel™ based macro enabled workbook
- Downloadable from the RPSEA project website

WQM

TSM


BSM


BEM

 **COLORADO SCHOOL OF MINES**  
EARTH • ENERGY • ENVIRONMENT

**Kennedy/Jenks Consultants**

**STRATUS CONSULTING**

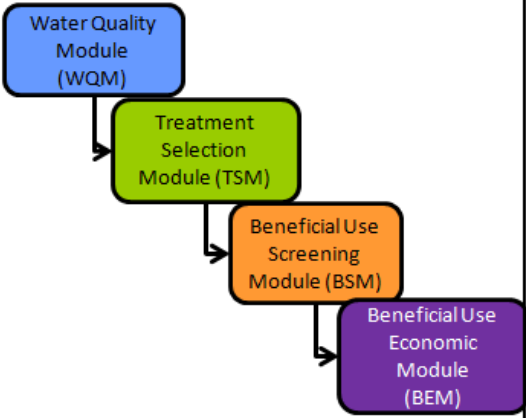
 **Argonne**  
NATIONAL LABORATORY

Sponsored by:  
  
**RPSEA**  
Research  
Partnership to  
Secure Energy  
for America

Produced Water Treatment and Beneficial Use Screening Tool

**Main Menu**

**TOOL ORGANIZATION**



**LEGEND CATEGORIES AND USEFUL LINKS**

**MODULES**

WQM

Link to WQM module

TSM

Link to TSM module

BSM

Link to BSM module

BEM

Link to BEM module

**SUPPORTING INFORMATION**

USER MANUAL

Manual for all modules

TOOL DESCRIPTION

Description of the tool

**USER ACTIONS**

Back

Back to previous page/menu

Next

On to next page/menu

User input

Clear all inputs

Clears all user inputs in this workbook

Restore all inputs

Restores all defaults in this workbook

**START!**  
(click here)

Disclaimer: The outputs and results obtained from this Integrated Decision Framework are meant for project screening purposes only as relevant information gathered for these modules are based on limited projects and best engineering judgment. Actual projects will contain details not captured in this analysis that may affect the treatment of produced water, regulatory compliance, project feasibility, and overall cost of the project.





# Fundamental Treatment Technologies

## Pretreatment (Selected)

### Basic Separation

- Settling
- Coagulation
- Hydrocyclone

### Adsorption

- Activated carbon
- Zeolite
- Ion exchange

### Advanced

- Chemical oxidation
- Microfiltration
- Ultrafiltration



# Desalination Treatment Technologies

## Membrane Separations

### High Pressure Membrane

- Reverse osmosis
- Nanofiltration
- VSEP

### Electrically Driven Processes

- Electrodialysis
- Electrodionization

### Novel Membrane Processes

- Membrane distillation
- Forward osmosis

## Thermal Technologies

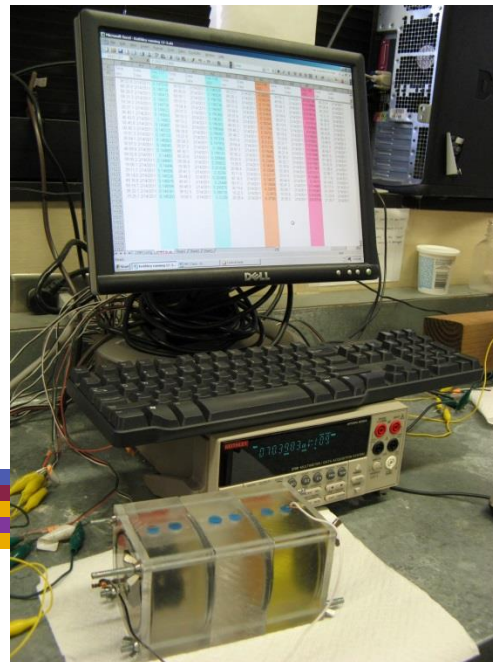
- Thermal Distillation
- Dewvaporation





# Ongoing Research on Produced Water Treatment

- Biological treatment of produced water and hydraulic fracturing flowback water
- Energy recovery and desalination of produced water using innovative microbial fuel cells
- Selective removal of ions from water using electrodialysis



# Summary and Recommendations

- Produced water treatment & reuse provides a potential source of water.
- The Permian Basin is producing a lot of oil and a lot of water.
- The water is located where water scarcity and demand are severe.
- Produced water contains both organic chemicals and salt, which require some type of treatment that depends on the intended use and water quality.
- Current storage and disposal, as well as reuse or beneficial uses, have environmental considerations.
- Partial treatment could be used to support potential beneficial uses such as onsite reuse, other industrial uses, and bioenergy production.
- Permit policy and regulation modifications would be needed to reuse produced water for beneficial uses in New Mexico.
- Research is needed to develop low cost partial treatment technologies, to evaluate environmental impact of reuse, and to determine which uses are feasible for produced water.
- Outreach and education are needed to increase awareness and understanding of this potentially viable “new” water source.